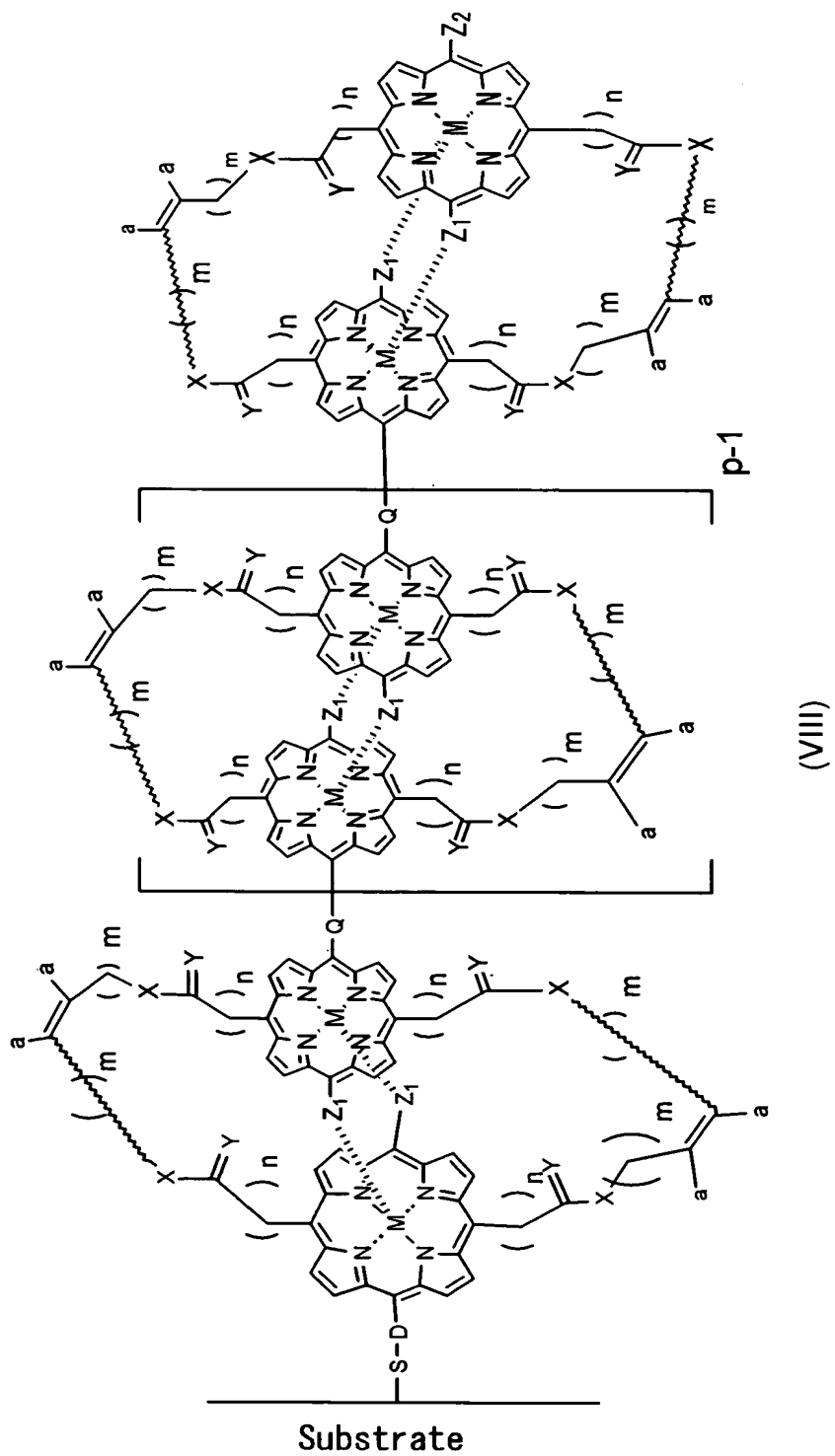


WHAT IS CLAIMED IS:

1. A photo-functional molecule element having, on
a substrate, a porphyrin polymer containing covalently-
fixed porphyrin units represented by the following
5 formula (VIII) or (VIII'):





[wherein

a represents H, an alkyl group or an aryl group;

X represents -O-, -S-, > NR₁₀₁ (wherein R₁₀₁ represents H or an alkyl group), -CH₂- or a single
5 bond;

Y represents =O, =S or 2H;

m represents an integer of 0 to 4;

n represents an integer of 0 to 6;

Z₁ represents a 5- or 6-membered nitrogen-
10 containing heteroaromatic ring group capable of forming
a coordination bond;

Z₂ represents a group having a functional group
which can be an electron acceptor or electron donor, or
a group which can be the terminal group of the
15 porphyrin polymer;

D represents a divalent group including at least
one of an arylene group and an alkylene group;

E represents a trivalent group including at least
one of an arylene group and an alkylene group;

20 M represents an ion of metal selected from the
group consisting of typical metals and transition
metals;

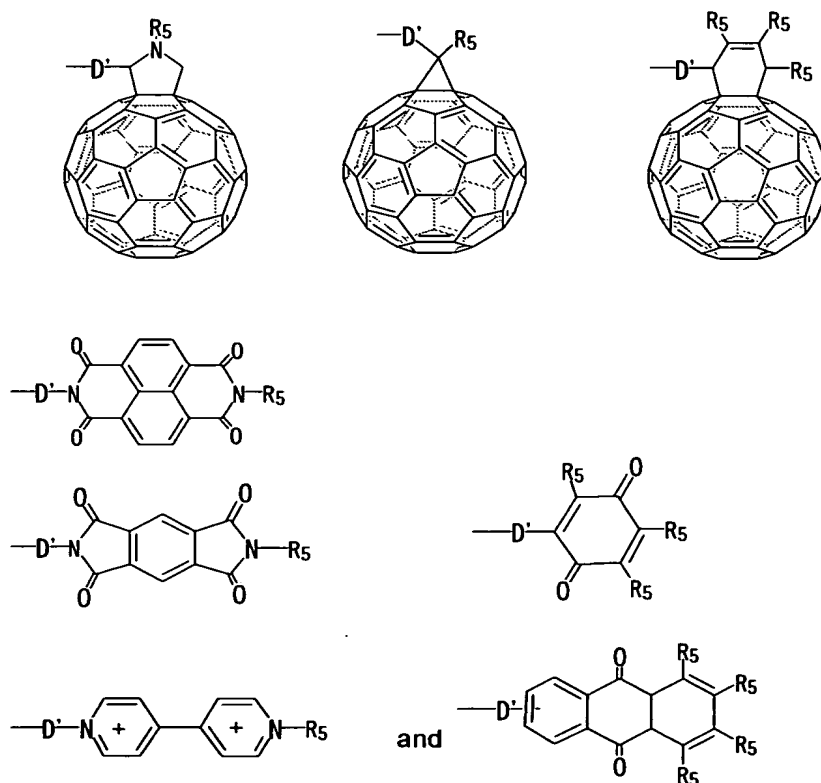
Q represents a single bond or a divalent linking
group; and

25 p represents an integer of 1 or more, and
wherein a plurality of the repeating unit
consisting of two porphyrin derivatives that are bonded

with the two covalent bonds may be the same or different to each other].

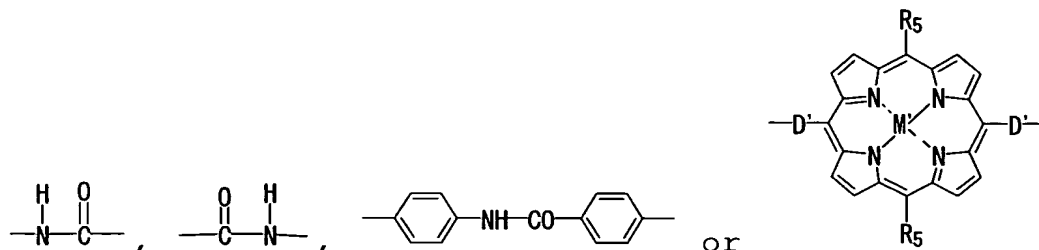
2. The photo-functional molecule element according to claim 1, wherein the 5- or 6-membered nitrogen-containing heteroaromatic ring group represented by Z₁ is selected from the group consisting of an imidazolyl group and a derivative thereof, an oxazolyl group, a thiazolyl group and 2-pyridinyl group.

3. The photo-functional molecule element according to claim 1, wherein the group having a functional group which can be an electron acceptor represented by Z₂ is selected from:



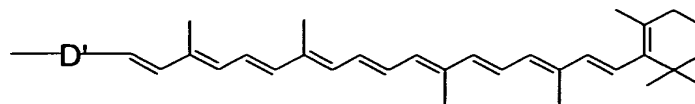
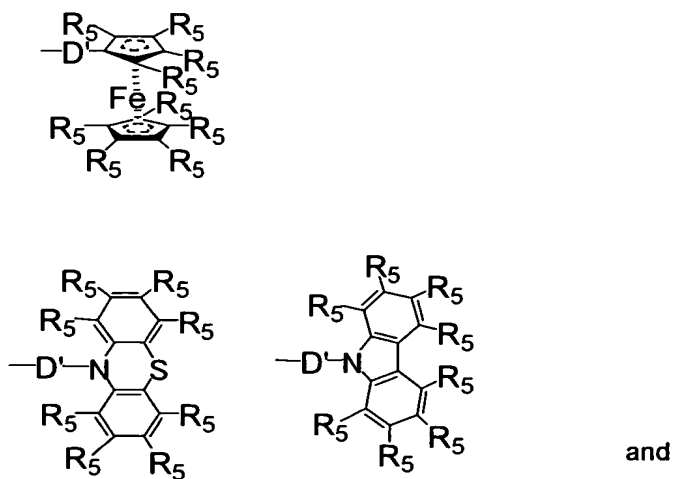
15 [(wherein D' represents a single bond, a divalent group including at least one of arylene group and alkylene

group,

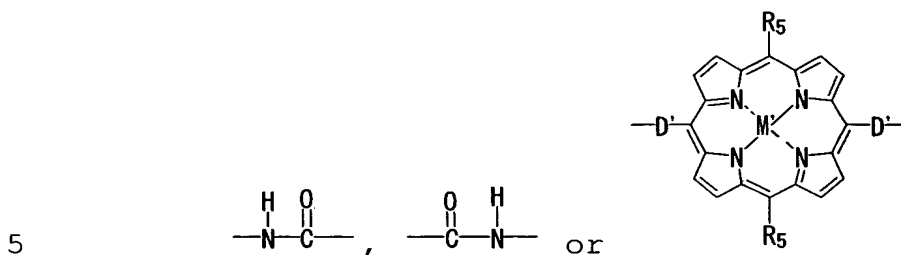


(wherein R₅ represents H, an alkyl group, an aryl group,
 5 a halogen atom, a cyano group or an alkoxy group,
 wherein two R₅s may be the same or different; and M'
 represents 2H or the ion of the metal represented
 by M)].

4. The photo-functional molecule element
 10 according to claim 1, wherein the group having
 a functional group which can be an electron donor
 represented by Z₂ is selected from:



[wherein D' represents a single bond, a divalent group including at least one of arylene group and alkylene group,



(wherein R₅ represents H, an alkyl group, an aryl group, a halogen atom, a cyano group or an alkoxy group, wherein two R₅s may be the same type or different; and M' represents 2H or the ion of the metal represented by M)].

5. The photo-functional molecule element according to claim 1, wherein the group having a functional group which can be the terminal group of the porphyrin polymer represented by Z₂ is selected from the group consisting of an alkyl group, an aryl group and an alkynyl group.

6. The photo-functional molecule element according to claim 1, wherein the divalent group including at least one of arylene group and alkylene group represented by D is a divalent group having at least an arylene group and/or an alkylene group at terminal ends thereof, and optionally having therebetween at least one group selected from an ether group, a carbonyl group, and a functional group having a hetero atom).

7. The photo-functional molecule element according to claim 1, wherein the trivalent group including at least one of arylene group and alkylene group is a trivalent group obtained by eliminating one hydrogen atom from the divalent group represented by D.

8. The photo-functional molecule element according to claim 1, wherein the metal that provides the ion represented by M is selected from the group consisting of typical metals belonging to 1A, 2A, 2B, 3B to 7B and 0 groups on the periodic table, and transition metals belonging to 3A to 7A, 8 and 1B groups on the periodic table.

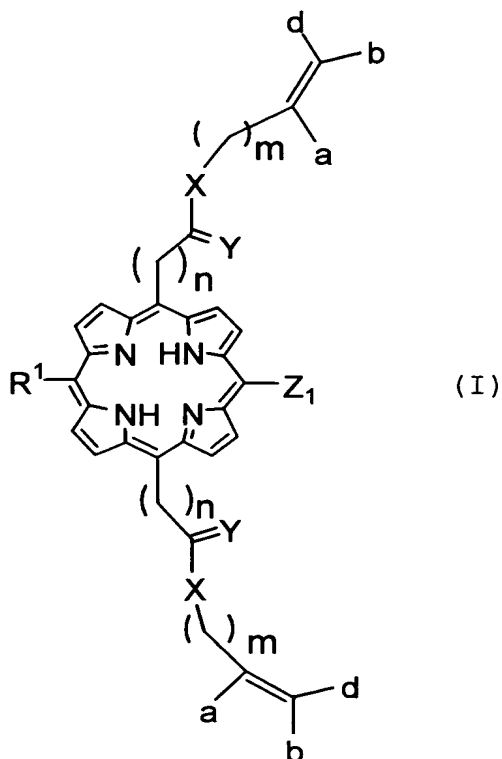
9. The photo-functional molecule element according to claim 1, wherein the divalent linking group represented by Q is selected from the group consisting of a divalent, saturated or unsaturated aliphatic hydrocarbon group, a divalent, saturated or unsaturated hydrocarbon ring group, a divalent, saturated or unsaturated hetero cyclic group, and a combination of at least one of these divalent groups and at least one divalent groups selected from -O- and -C(=O)-.

10. The photo-functional molecule element according to claim 1, wherein the substrate is a metal selected from gold, silver, copper, platinum, palladium, nickel and aluminum, or a solid substrate onto which one of the metals is vapor-deposited; semiconductor

selected from TiO_2 , SnO_2 , indium tin oxide, CdS , CdSe ,
GaAs, GaP, Si, InP and CdTe , or semiconductor into
which an electron acceptor or an electron donor is
added; and a solid substrate onto which a polymer
5 selected from conductive polymer, semiconductive
polymer, polythiophene-type polymer, polypyrrole-type
polymer, polyacetylene-type polymer and
polydiacetylene-type polymer is coated.

11. A method of preparing a photo-functional
10 molecule element having, on a substrate, a porphyrin
polymer containing covalently-fixed porphyrin units,
which method comprises:

(1) fixing, on a substrate, a linker molecule
represented by the following formula (I):



[wherein

a, b and d independently represent H, an alkyl group or an aryl group;

5 X represents -O-, -S-, > NR₁₀₁ (wherein R₁₀₁ represents H or an alkyl group), -CH₂- or a single bond;

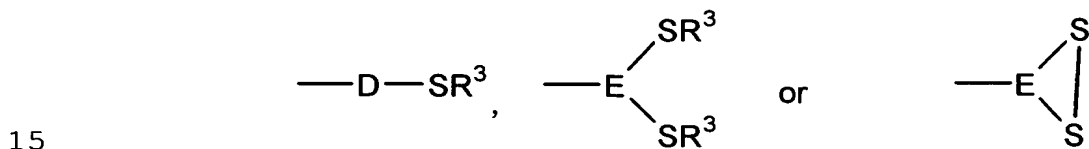
Y represents =O, =S or 2H;

m represents an integer of 0 to 4;

n represents an integer of 0 to 6;

10 Z₁ represents a 5- or 6-membered nitrogen-containing heteroaromatic ring group capable of forming a coordination bond; and

R¹ represents

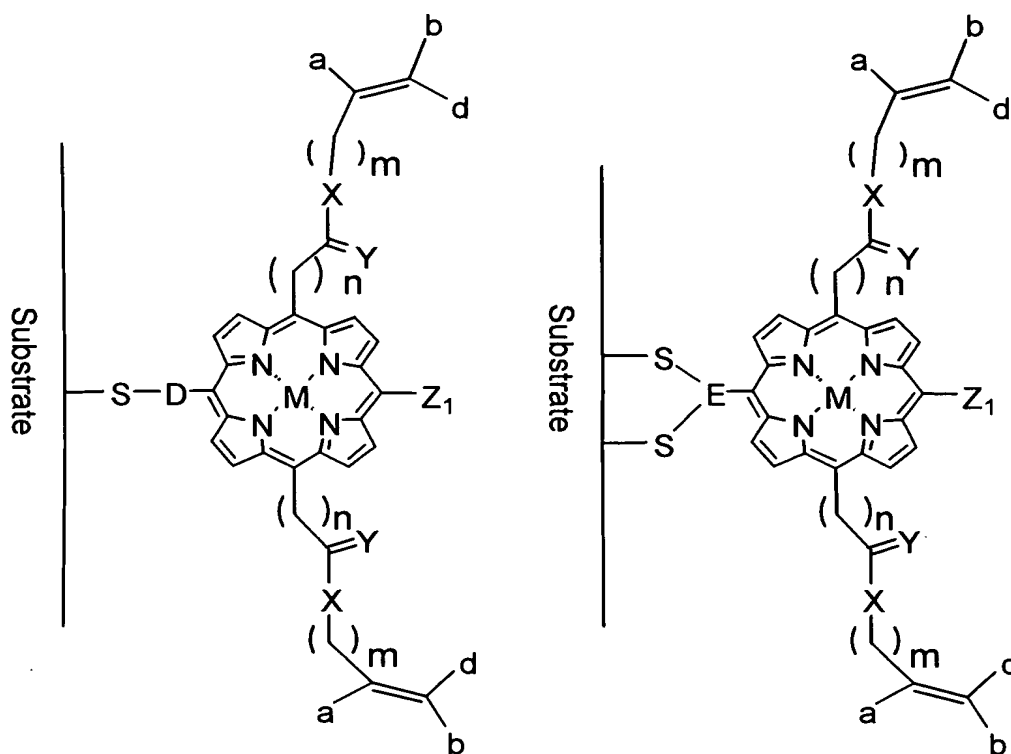


(wherein D represents a divalent group including at least one of arylene group and alkylene group;

E represents a trivalent group including at least one of arylene group and alkylene group; and R³ represents
20 H or an acetyl group)]; and

introducing a metal, M, selected from the group consisting of typical metals and transition metals to the porphyrin residue derived from the linker molecule,

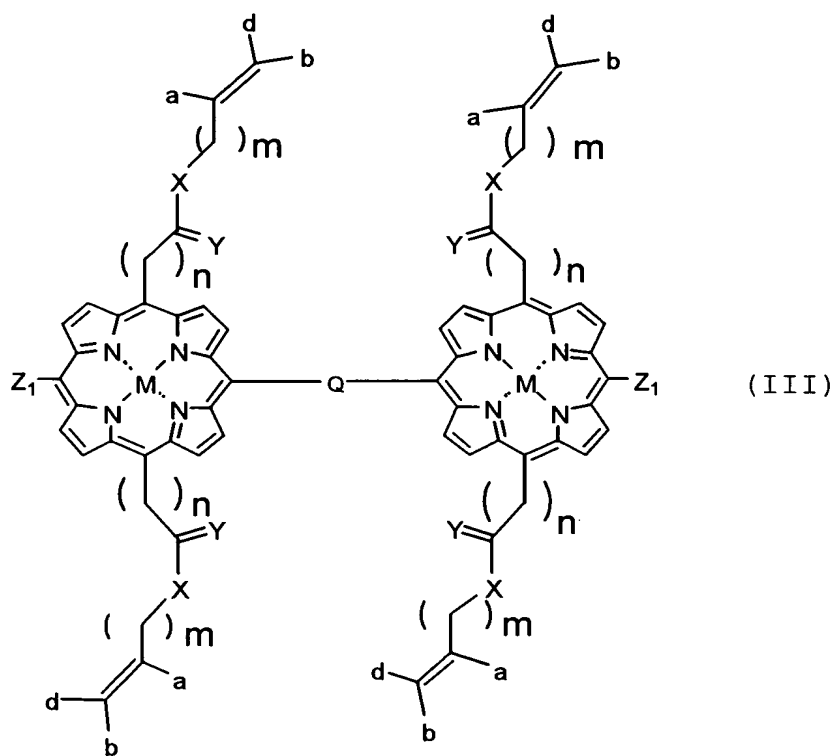
thereby obtaining a monomolecular film represented
25 by the following formula (II) or (II'):



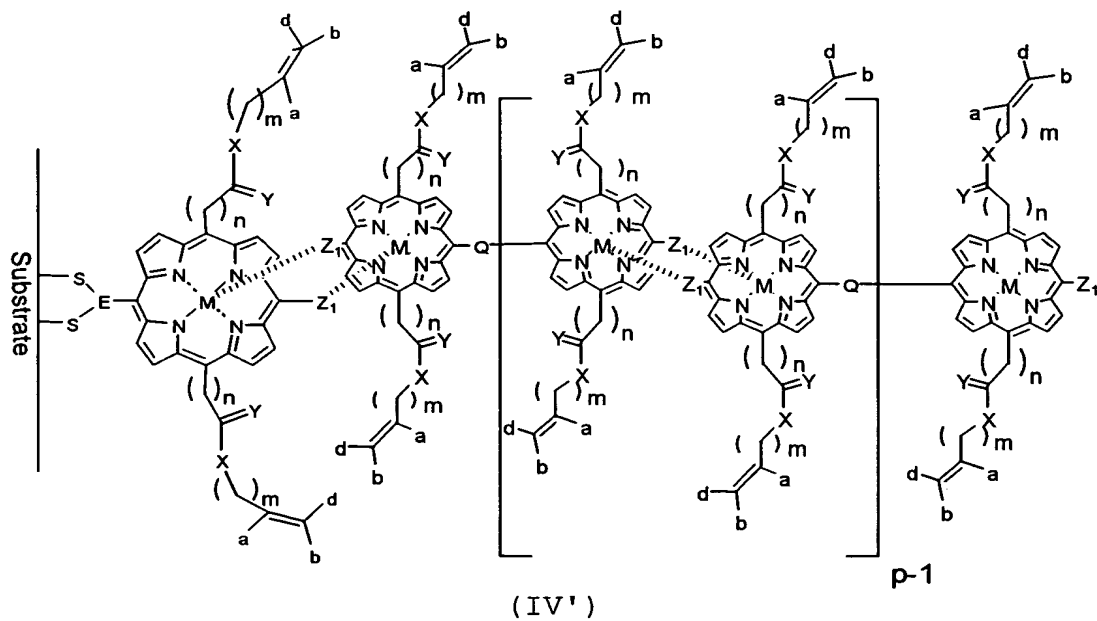
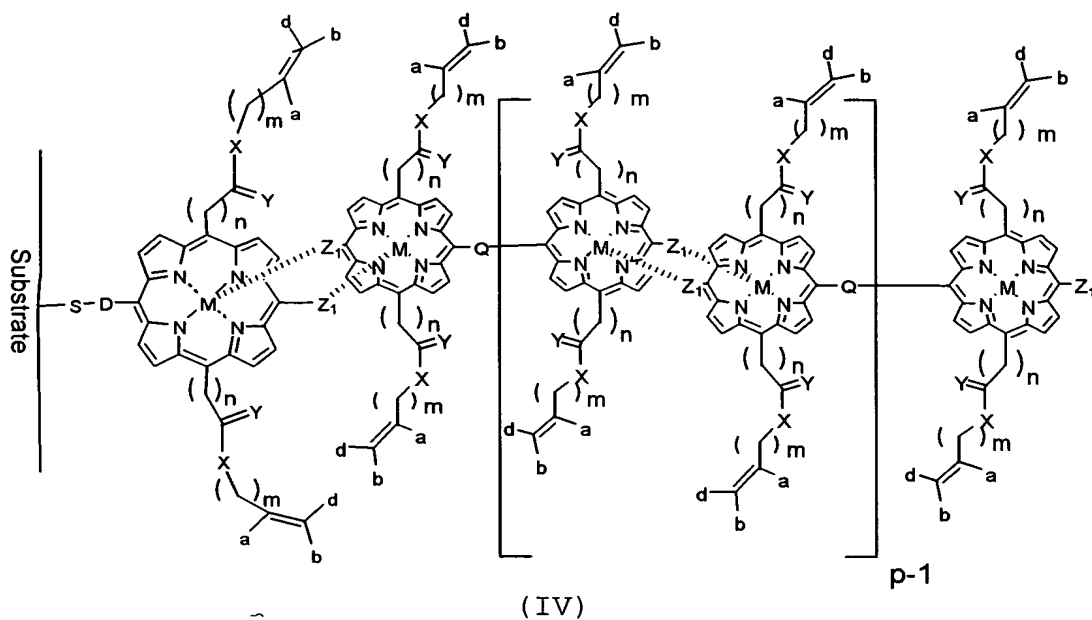
(wherein each of the substituents is as defined above),

provided that either one of the fixing a linker
 5 molecular and the introducing a metal M may be carried
 out earlier than the other;

(2) linking the porphyrin residue of the
 monomolecular film with one of porphyrin residues of
 meso-meso linked bis-porphyrin represented by the
 10 following formula (III):

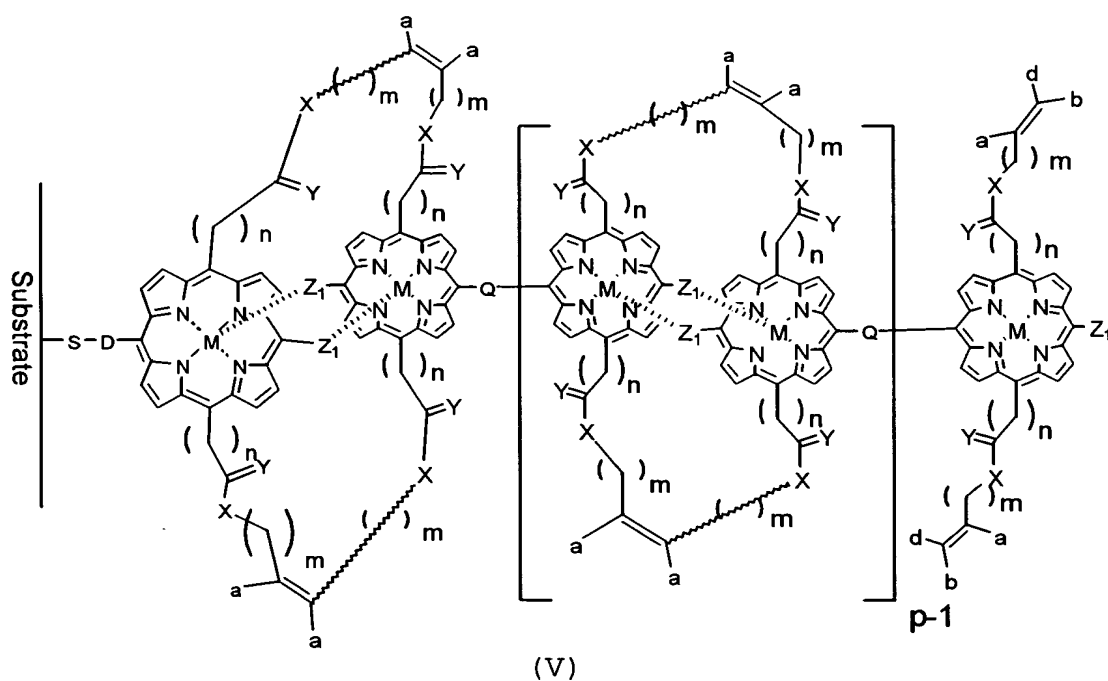


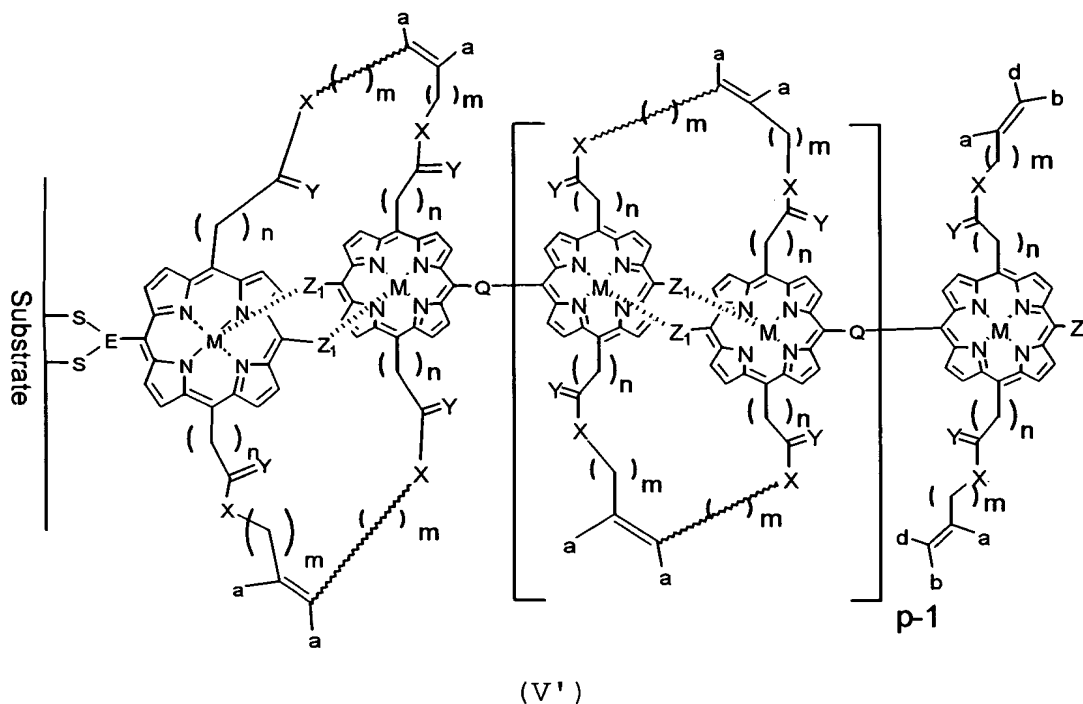
(wherein each of a, b, d, X, Y, m, n, M and Z₁ is as defined above and Q represents a single bond or
 5 divalent linking group), via two coordinate bonds, thereby obtaining a first laminate represented by the following formula (IV) or (IV'):



(wherein each of the substituent is as defined above,
and p is 1);

(3) effecting, in the presence of a Grubbs catalyst, a ring-closing metathesis reaction of the olefin portions of the porphyrin residue derived from





(wherein each of the substituents is as defined above,
 5 and p is 1);

(4) optionally,

linking the porphyrin residue at the terminal end
 of the fixed first laminate with one of the porphyrin
 residues of another meso-meso linked bis-porphyrin
 10 represented by the formula (III), via two coordinate
 bonds, in the same manner as in above (2), thereby
 obtaining a second laminate represented by the above
 formula (IV) or (IV'), wherein p represents an integer
 of 2 or more); and

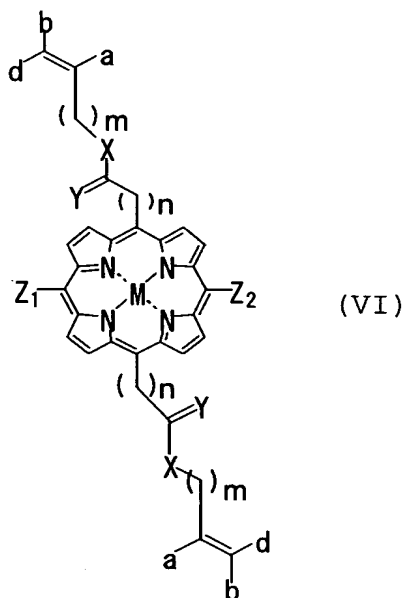
15 effecting, in the presence of a Grubbs catalyst,
 a ring-closing metathesis reaction in the same manner
 as in above (3), thereby obtaining a fixed second
 laminate represented by the formula (V) or (V'),

wherein p represents an integer of 2 or more);

wherein the linking and the effecting the ring-closing metathesis reaction, as one cycle, are sequentially repeated q times, thereby obtaining

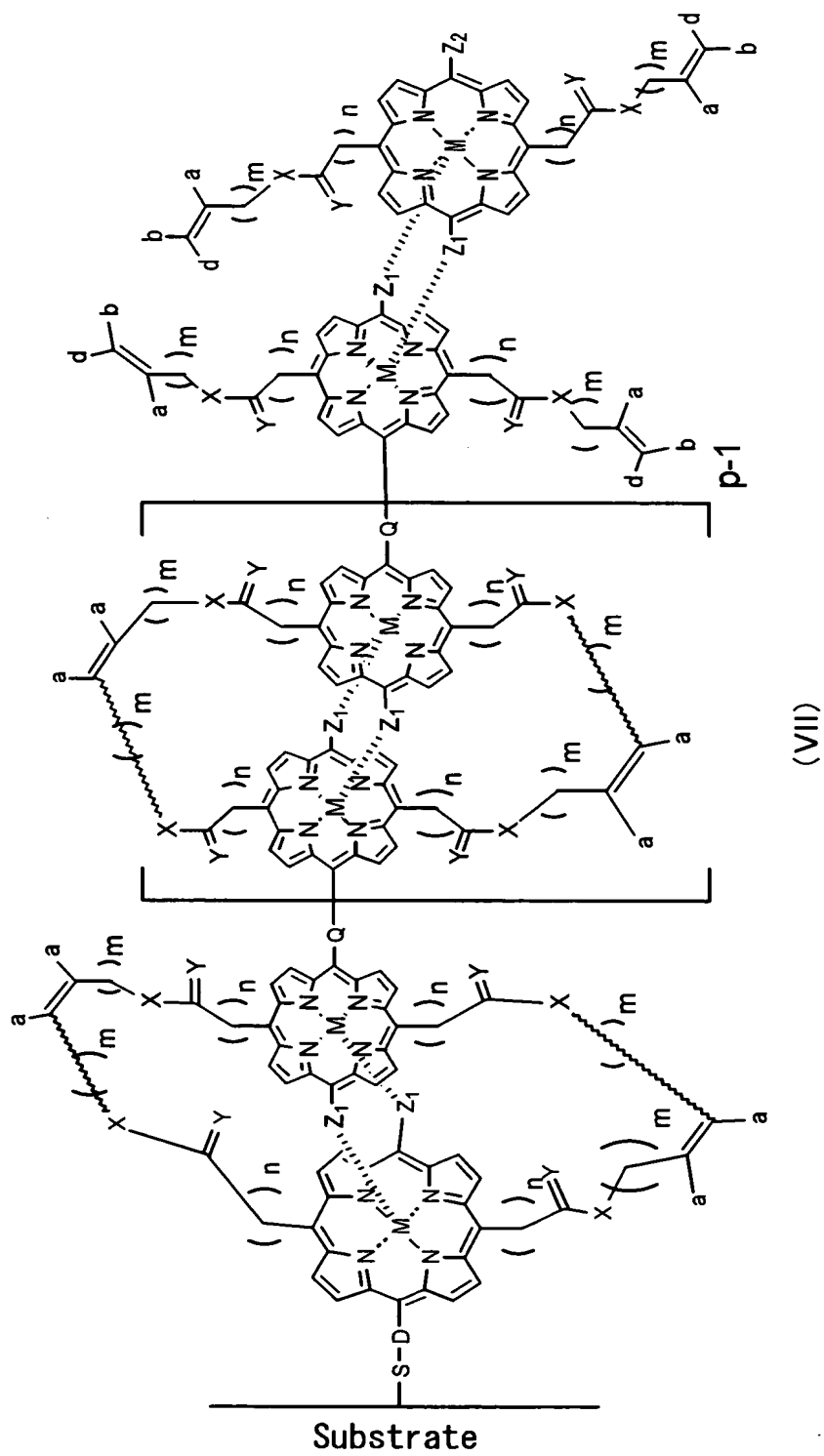
5 a fixed q^{th} laminate represented by the formula (V) or (V'), wherein p represents q, and q is an integer of 2 or more;

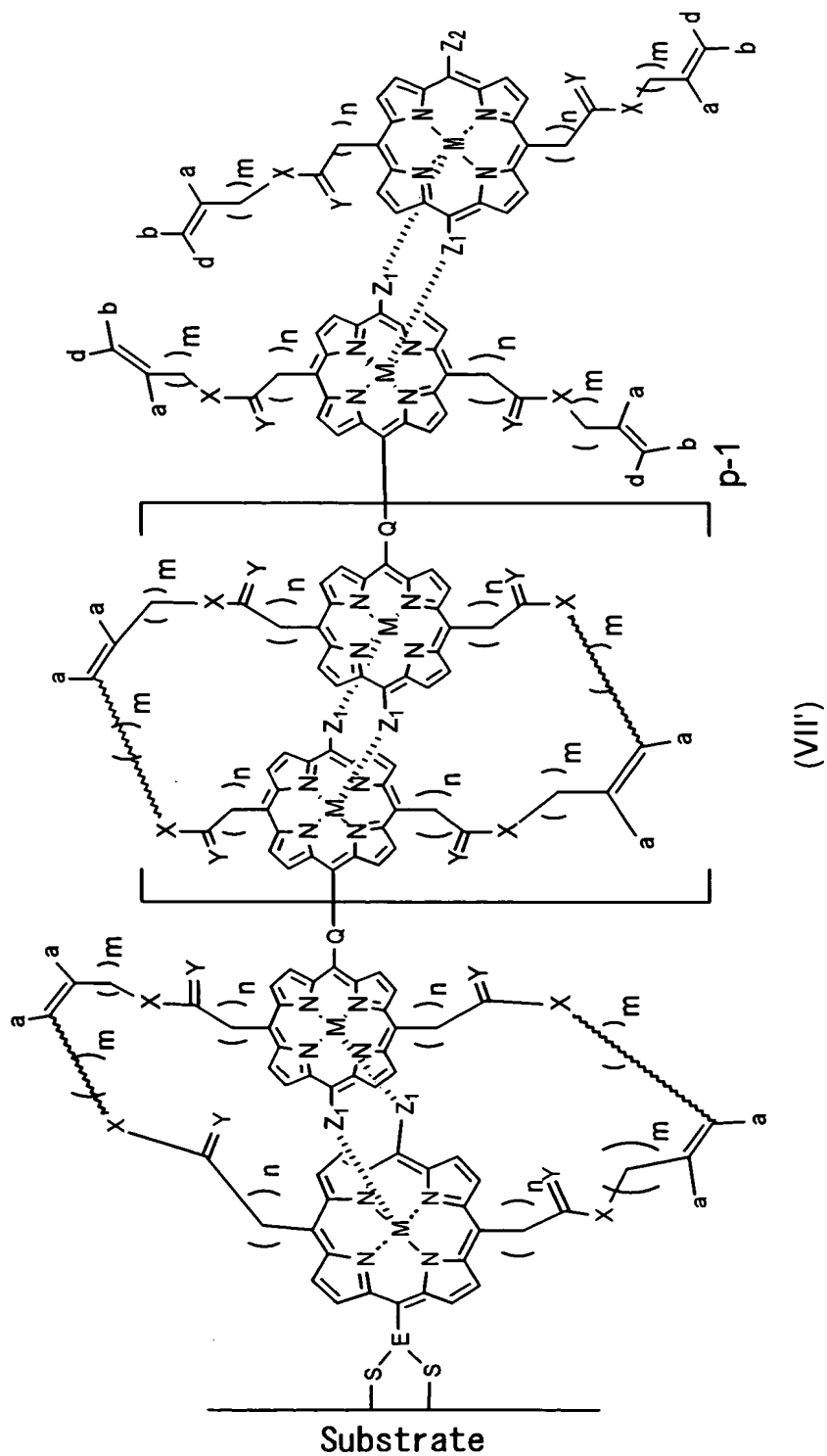
(5) linking the porphyrin residue at the terminal end of the fixed first laminate obtained in above (3) or the fixed q^{th} laminate obtained in above (4), with
10 the porphyrin residue of a porphyrin derivative represented by the following formula (VI):



15 (wherein each of Z_1 , M, X, Y, m, n, a, b and d is as defined above, and Z_2 represents a group having a functional group which can be an electron acceptor or electron donor, or a group which can be the terminal group of the porphyrin polymer), via two coordinate

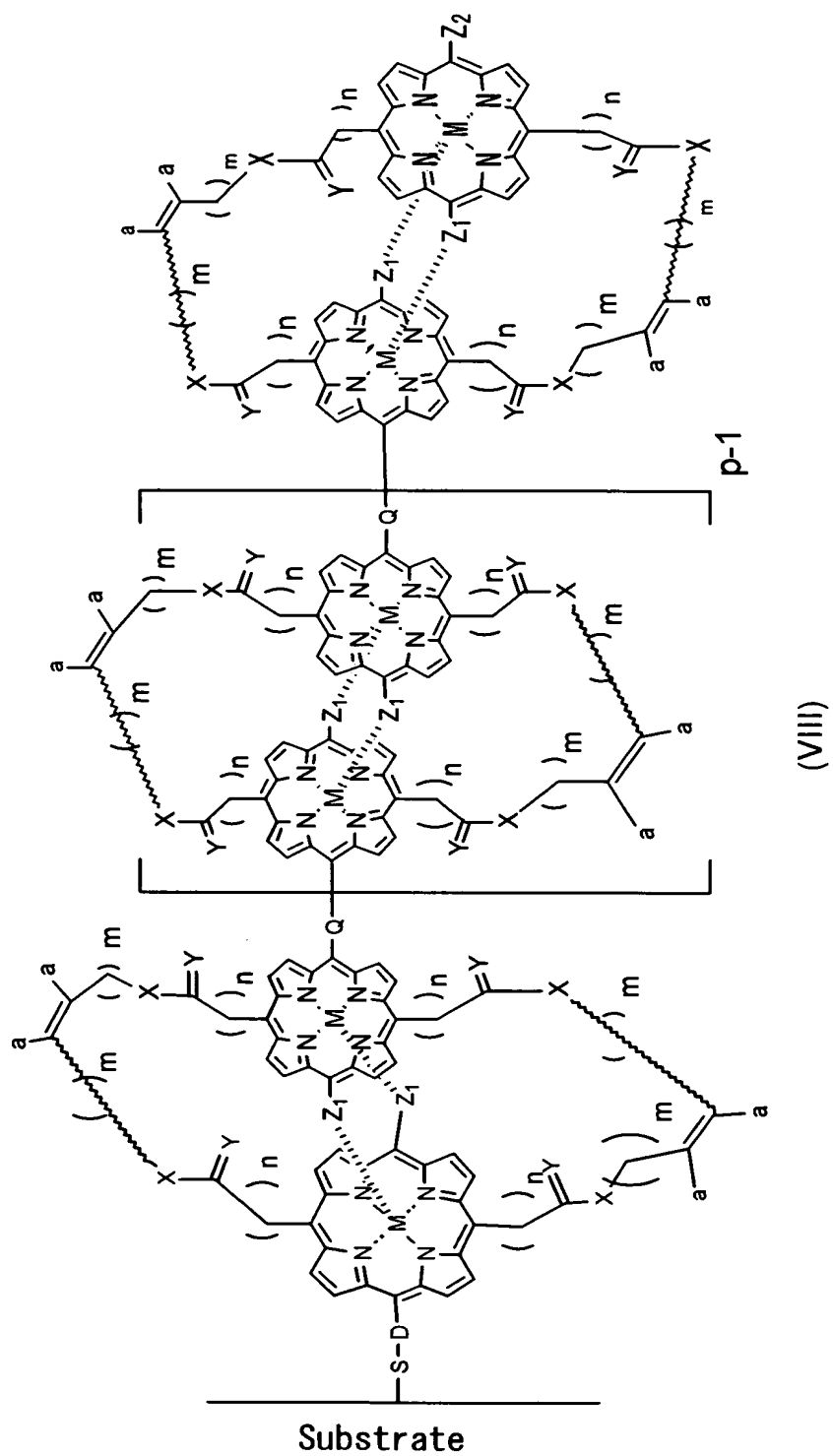
bonds, thereby obtaining a photo-functional molecule precursor represented by the following formula (VII) or (VII'):

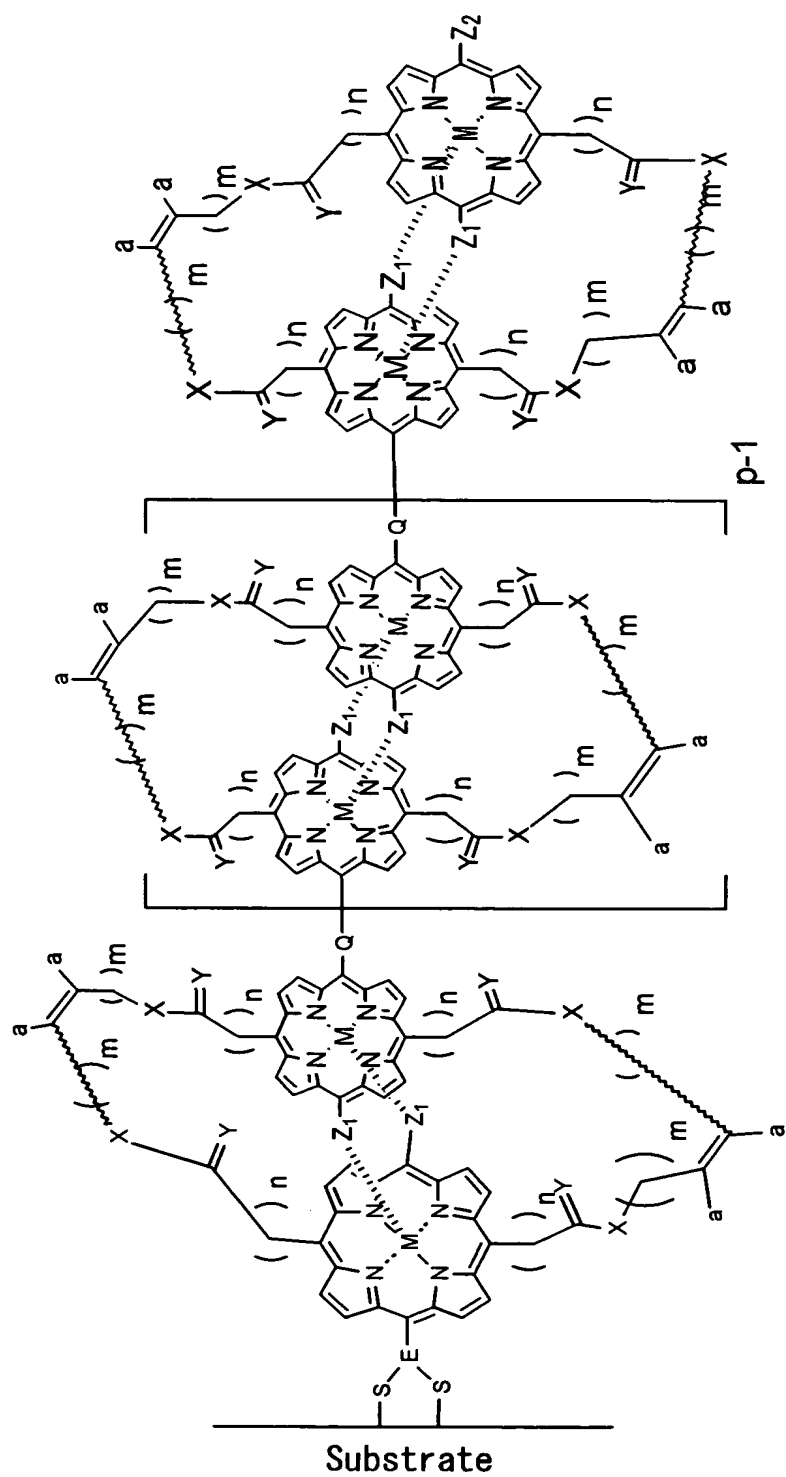




(wherein each of the substituents is as defined above);
and

(6) effecting, in the presence of a Grubbs
catalyst, a ring-closing metathesis reaction of the
5 olefin portion derived from the porphyrin derivative
represented by the formula (VI), with the olefin
portion of the porphyrin residue that is coordinated
to the porphyrin derivative, so that the porphyrins
are fixed to each other by covalent bonds, thereby
10 obtaining a photo-functional molecule element
represented by the following formula (VIII) or (VIII'):

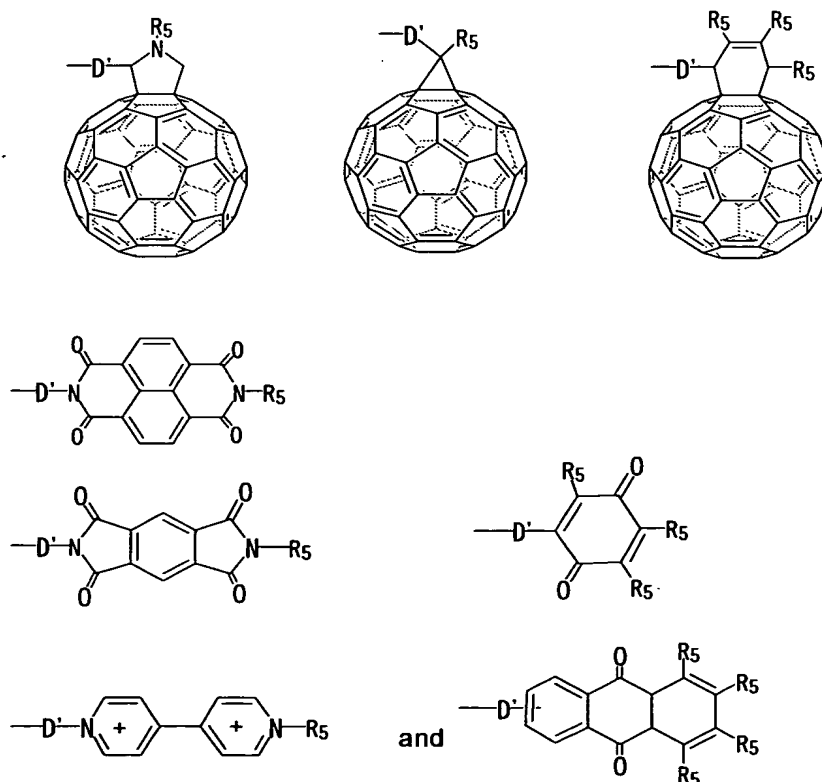




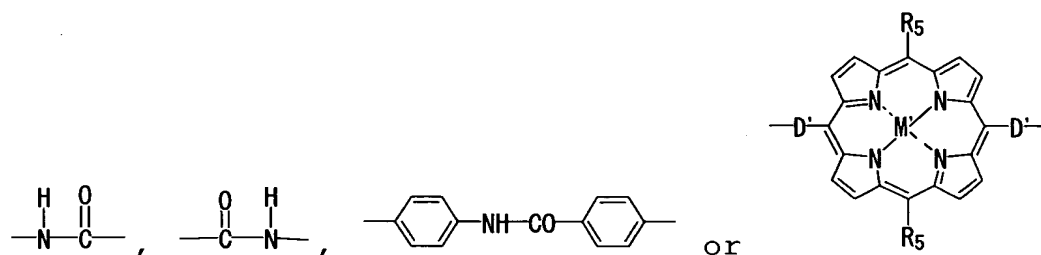
(wherein each of the substituents is as defined above).

12. The photo-functional molecule element according to claim 11, wherein the 5- or 6-membered nitrogen-containing heteroaromatic ring group represented by Z₁ is selected from the group consisting of an imidazolyl group and a derivative thereof, an oxazolyl group, a thiazolyl group and 2-pyridinyl group.

13. The photo-functional molecule element according to claim 11, wherein the group having a functional group which can be an electron acceptor represented by Z₂ is selected from:

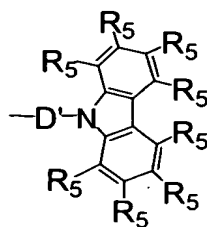
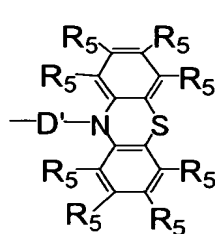
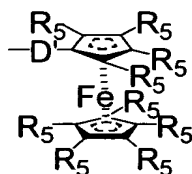


[(wherein D' represents a single bond, a divalent group including at least one of arylene group and alkylene group,

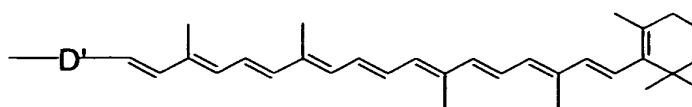


(wherein R_5 represents H, an alkyl group, an aryl group, a halogen atom, a cyano group or an alkoxy group, wherein two R_5 s may be the same or different; and M' represents 2H or the ion of the metal represented by M)].

14. The photo-functional molecule element according to claim 11, wherein the group having a functional group which can be an electron donor represented by Z_2 is selected from:

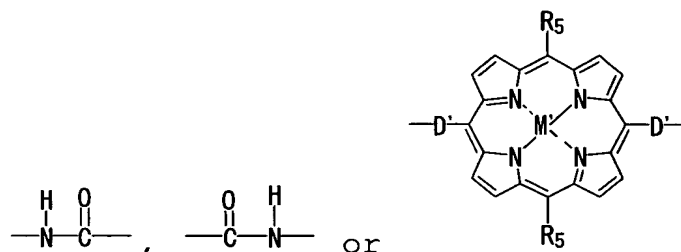


and



[wherein D' represents a single bond, a divalent group including at least one of arylene group and alkylene

group,



(wherein R_5 represents H, an alkyl group, an aryl group,
 5 a halogen atom, a cyano group or an alkoxy group,
 wherein two R_5 s may be the same type or different;
 and M' represents 2H or the ion of the metal
 represented by M)].

15. The photo-functional molecule element
 10 according to claim 11, wherein the group having
 a functional group which can be the terminal group of
 the porphyrin polymer represented by Z_2 is selected
 from the group consisting of an alkyl group, an aryl
 group and an alkynyl group.

15 16. The photo-functional molecule element
 according to claim 11, wherein the divalent group
 including at least one of arylene group and alkylene
 group represented by D is a divalent group having
 at least an arylene group and/or an alkylene group
 20 at terminal ends thereof, and optionally having
 therebetween at least one group selected from an ether
 group, a carbonyl group, and a functional group having
 a hetero atom).

17. The photo-functional molecule element
 25 according to claim 11, wherein the trivalent group

including at least one of arylene group and alkylene group is a trivalent group obtained by eliminating one hydrogen atom from the divalent group represented by D.

18. The photo-functional molecule element
5 according to claim 11, wherein the metal that provides the ion represented by M is selected from the group consisting of typical metals belonging to 1A, 2A, 2B, 3B to 7B and 0 groups on the periodic table, and transition metals belonging to 3A to 7A, 8 and 1B
10 groups on the periodic table.

19. The photo-functional molecule element according to claim 11, wherein the divalent linking group represented by Q is selected from the group consisting of a divalent, saturated or unsaturated
15 aliphatic hydrocarbon group, a divalent, saturated or unsaturated hydrocarbon ring group, a divalent, saturated or unsaturated hetero cyclic group, and a combination of at least one of these divalent groups and at least one divalent groups selected from -O-
20 and -C(=O)-.

20. The photo-functional molecule element according to claim 1, wherein the substrate is a metal selected from gold, silver, copper, platinum, palladium, nickel and aluminum, or a solid substrate onto which
25 one of the metals is vapor-deposited; semiconductor selected from TiO₂, SnO₂, indium tin oxide, CdS, CdSe, GaAs, GaP, Si, InP and CdTe, or semiconductor into

which an electron acceptor or an electron donor is
added; and a solid substrate onto which a polymer
selected from conductive polymer, semiconductive
polymer, polythiophene-type polymer, polypyrrole-type
5 polymer, polyacetylene-type polymer and
polydiacetylene-type polymer is coated.